PORTO RICO AGRICULTURAL EXPERIMENT STATION,
D. W. MAY, Agronomist in Charge,
Mayaguez, P. R.

BULLETIN No. 26.

Under the supervision of the STATES RELATIONS SERVICE,
Office of Experiment Stations, U. S. Department of Agriculture.

VANILLA:

A PROMISING NEW CROP FOR PORTO RICO.

BY

T. B. McCLELLAND, Horticulturist.

Issued April 17, 1919.

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[Under the supervision of A. C. TRUE, Director of the States Relations Service, United States Department of Agriculture.]

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LETTER OF TRANSMITTAL.

PORTO RICO AGRICULTURAL EXPERIMENT STATION,
Mayaguez, P. R., September 10, 1918.

SIR: I submit herewith a manuscript on vanilla growing in Porto Rico. This embodies the results of several years' experience, the rather extended investigation having been necessitated by the fact that very little had been done in the scientific study of this exotic. Though its value depends upon the careful treatment of the bean in the curing process, so much is frequently left to chance that great variation often results in the product found on the market. As shown herein, vanilla is a very promising introduction into Porto Rico, as it may be employed by the coffee growers of the island to diversify without in any way injuring their main crop and it will furnish employment for the women and children of the rural population.

I recommend that the manuscript be published as Bulletin No. 26 of this station.

Respectfully,

D. W. MAY,
Agronomist in Charge.

Dr. A. C. TRUE,
Director States Relations Service,
U. S. Department of Agriculture, Washington, D. C.

Publication recommended.
A. C. TRUE, *Director.*

Publication authorized.
D. F. HOUSTON,
Secretary of Agriculture.

VANILLA: A PROMISING NEW CROP FOR PORTO RICO.

CONTENTS.

INTRODUCTION.

For many years Porto Rico has produced only a limited number of crops for export, the market fluctuations of two or three staple products meaning prosperity or ruin for the island. In an insular community of this kind, where interchange of products is necessarily more restricted than elsewhere, the chances for the introduction of new crops are relatively small. The money crop of one island may be almost unknown or entirely ignored on another with almost identical soil and climatic conditions. Thus vanilla, a successful crop in many tropical communities resembling Porto Rico, has so far made no headway here.

Vanilla is produced commercially from within a few degrees of the equator to more than 20° north and south of it. It is planted from near sea level to altitudes of 2,000 feet or more. With the exception of those in Mexico, all of the most extensive plantings have been made on islands. Porto Rico, as an island bisected by the eighteenth parallel of latitude, should furnish conditions suitable for commercial vanilla growing.

So far as the writer has been able to ascertain, vanilla growing on a commercial scale had never been attempted here prior to the present time. In fact, the species of economic value are locally almost unknown. In a very few scattered gardens over the island vanilla is to be found as a curiosity, but to the general public it is an unknown exotic. Wild vanilla has been noted in the vicinity of Bayamón, Dorado, Lares, Maricao, Mayaguez, San Germán, Guánica, and Guayanilla. This in itself is an indication of the suitability of local conditions for the vanilla plant.

Vanilla is a climbing orchid, one of the few members of this family valued for reasons other than the beauty of its blossoms. From the cured pod, or bean, as the fruit is called from its external resemblance to a bean pod, a flavoring extract is obtained of which at least three times as much is consumed as of all other flavors together.[1] This extract is used in preparing confectionery, chocolate, liqueurs and perfumery, and for flavoring desserts and soft drinks. The use of vanilla as a flavoring agent was one of the gifts of the New World to the Old, as the product was unknown to Europeans until the Spaniards introduced it, they having found the Aztecs in Mexico using it in the preparation of chocolate.

MARKET PROSPECTS.

The prospective planter of vanilla is of course most interested in the possibility of selling his product at a fair profit. To form an opinion on this, he will want to know the quantity which the market demands and the price paid.

The price of vanilla beans is to-day much less than formerly. This is to be attributed to increased production and the manufacture of synthetic vanillin. Synthetic vanillin, which is identical with the natural product, is now produced on a large scale, chiefly from eugenol or oil of cloves, though it can be obtained from various substances. For some purposes vanillin is a satisfactory substitute for the extract made from vanilla beans, but for other purposes only the best vanilla can be used. The vanillin content of the beans, which ranges in the economic species from 1 to 3 per cent, does not determine their value, as the highest priced beans are said not to contain the most vanillin.[2] It is claimed that the superiority of the extract of vanilla beans to a simple solution of vanillin is due to secondary aromatic flavoring compounds which are present in the bean in very small amounts.

While the discovery of the synthetic preparation of vanillin, the primary flavoring compound of the vanilla bean, has unquestionably greatly reduced the price of vanilla beans, the consumption of the latter is increasing greatly, as shown by the quantity imported into the United States. Figure 1 [3] shows the fluctuations in value and the quantity imported.

Even while the average valuation per pound for the total annual imports has fallen as low as $1.33, the Mexican vanilla has up to 1917 never fallen below $2.28, a fact showing that a product of good

[1] U. S. Dept. Agr. Yearbook, 1908, p. 333.

[2] Dean, J. R., and Schlotterbeck, J. O. Vanilla extract. Jour. Indus. and Engin. Chem., 8 (1916), No. 7, p. 608.

[3] Years ending June 30. Data compiled from U. S. Dept. Agr., Bur. Statistics Buls. 74 (1910) and 95 (1912), and Sect. Foreign Markets Buls. 17 (1900) and 24 (1901); and from correspondence with the Bureau of Crop Estimates of the Department of Agriculture and the Bureau of Foreign and Domestic Commerce of the Department of Commerce.

quality will always remain well above the average valuation. It may, of course, never reach again $9.05 a pound, the price of Mexican vanilla in 1900.

Nearly all of the vanilla imported into the United States comes from Mexico, from French possessions, or through France. Mexico is reputed to lead as to quality, but French Oceania leads in quantity.

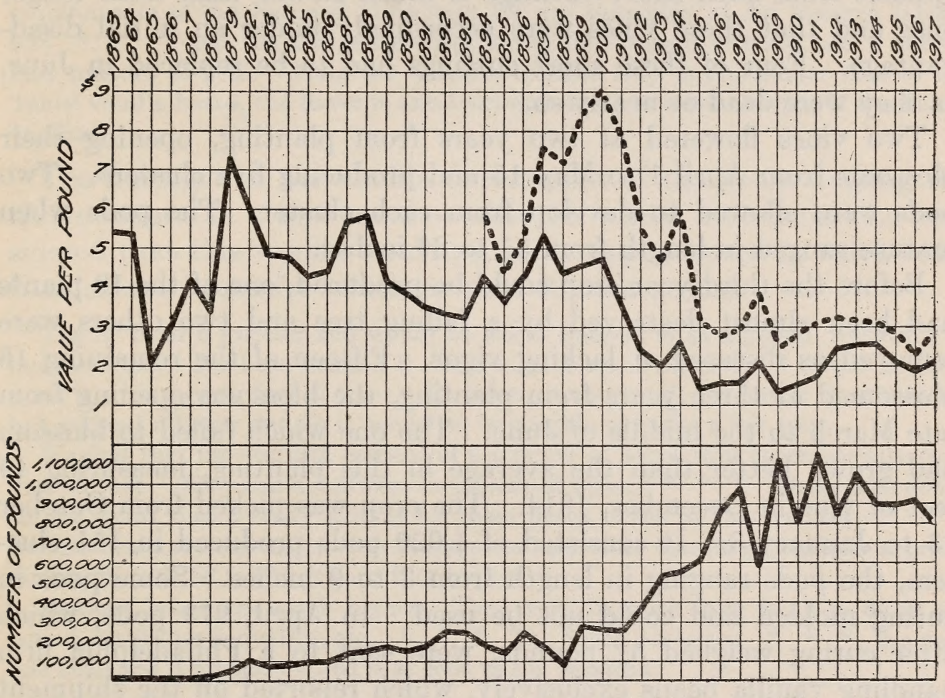

FIG. 1.—Vanilla beans imported into the United States.

In 1913 vanilla beans to the value of more than $2,500,000 were imported into the United States. As there is an import duty of 30 cents a pound on vanilla, Porto Rican vanilla will have exactly that advantage over the imported product.

HISTORY OF EXPERIMENTAL PLANTING AT THE STATION.

In December, 1909, a collection of cuttings of miscellaneous vanilla species was received from the Subtropical Garden at Miami, Fla. As many of the species are of slight or no commercial value, it was thought advisable to work principally toward the establishment of *Vanilla planifolia*, this being the species which produces the most valuable bean. The cuttings of this species had been received at the Subtropical Garden from a vanillery some 10 or 12 miles from Papantla, Mexico (as S. P. I. No. 14442), and as well as could be traced, from an importation into Hawaii from the Fiji Islands. No varietal difference whatever has been seen between the two.

The scarcity of propagating material greatly retarded work. By the summer of 1912, the original plantings had grown sufficiently to furnish short cuttings for a small new planting. In May of that year, 19 cuttings of the Mexican *Vanilla planifolia* were set out. To make the material go as far as possible, the average cutting was of only 4 or 5 nodes. Subsequent plantings have shown that development from such short cuttings is much slower than from longer ones and that these vines were accordingly under an initial disadvantage. Four of these short cuttings had to be replaced in June, as they were dead or nearly so.

Two vines flowered at two years from planting, opening their blossoms from April 1 to May 15 and producing five clusters. Two pods were allowed to develop from each cluster. The pods when mature ranged in length from $5\frac{3}{8}$ to $8\frac{3}{4}$ inches.

Before the third-year crop could be produced, one of the 19 plants had been almost destroyed by a falling tree and two others were removed as diseased or lacking vigor. Fifteen of the remaining 16 blossomed at three years from planting, the blossoms opening from late March to the middle of June. The one which failed to blossom had grown better than the average in this planting, measuring 49 feet of vine in December, 1914. The crop was picked from October 13 to January 3. It consisted of 1,020 pods produced in 151 clusters, the pods ranging in length from 3 to 9 inches. Some pods in curing molded and could not be used. In April, 973 pods, which after curing weighed $5\frac{1}{4}$ pounds, were sent to a Philadelphia firm handling vanilla beans exclusively, which reported on the shipment as follows:

> While the flavor is very pungent, being very similar to the Java variety, we believe that results from same would prove very satisfactory. * * * Any well-cured vanilla, so long as it is of sweet flavor and sound keeping qualities, is always marketable. * * * Regarding the vanilla sent us, value of same compares favorably with Bourbon or Java vanilla in same grades, or of the vanilla produced in Guadeloupe. We are allowing you $2.50 per pound.

On the above basis, the value of the crop per vine at $3\frac{1}{2}$ years from setting averaged 87.5 cents. These vines were set 9 by 9 feet, or at the rate of 537 vines to the acre. Excluding the vine accidentally demolished, if raised to the acre rate with five-sixths of the planting in production, as in this instance, the gross value of the crop of vanilla beans would have amounted to nearly $400.

The 1916 blossoming began in January and continued into June. The crop picking was from October 23 to December 26. All 16 of the 4-year-old plants blossomed, producing 936 pods in 233 clusters. After curing, this amounted to about $8\frac{3}{4}$ pounds of cured vanilla beans, or an average of more than half a pound per plant.

Instead of selling this crop it was divided into small samples which were sent to prominent American wholesale houses handling vanilla beans and to extract manufacturers for examination. Extracts from their reports follow:

These vanillas have a very nice aroma, resembling somewhat the vanilla beans known as South American, but originating in the island Guadeloupe * * * an excellent appearance, and were of fine flavor. An extract made according to the requirements of the National Formulary IV was examined at our research laboratory * * * and the analysis showed a vanillin content of 0.096 and a normal lead number of 0.43. While the vanillin content only approximates that of the Tahiti vanilla beans, the flavor is excellent and does not resemble that of the Tahiti vanillas.

The manager of the vanilla department of the house making the above report, in a conversation with the writer, stated that he considered that this vanilla would probably approximate in value some Guadeloupe beans for which he paid $3.60 a pound.

The A[1] bean is sweeter and would be worth from $3 to $4 a pound, according to moisture, etc. The bean marked B seems to have a sour odor, and I would not look upon it with a great deal of favor. However, it may work out better than it looks, but without a larger sample it would be impossible to make a fair test.

We find that the vanillin content of a number of beans runs spasmodically from year to year. They can not always be depended upon. * * * There is no doubt in the world that a ready market for these beans exists in this country. * * * Vanilla beans are coming in from Madagascar and other French possessions at prices ranging from $1.50 to $2 per pound for import.

Mexican beans are much higher. They vary in price from $3.75 to $5.50 per pound, according to quality, etc. * * * The South American * * * is a very fine bean and if properly cured is as good as the Mexican.

We are very anxious to get about 100 pounds of vanilla beans as per samples submitted, so that we could work them up as under actual working conditions.

We will pay you a high market price for them. We have no idea what price they are selling at.

We think the quality would compare favorably with the vanilla from the island of Guadeloupe, French West Indies, in which case it would be valued in normal times at about the price of ordinary Mexican vanilla beans, or the better quality of vanilla from Madagascar.

Just at the moment values are showing a greater difference than usual. Madagascar vanilla is low and worth to-day $2 per pound, on account of the smaller consumption in Europe, while the Mexican vanilla, owing to the short crop, the general scarcity in this market, and the desire of the consumers not to change their formulas, is worth to-day for the low grades $4.75 per pound. If the Porto Rican vanilla *were properly cured* we could pay to-day $2.75 per pound, New York.

If you can produce vanilla in sufficient quantity to make it worth while, we would be glad to send a competent person to Mayaguez who could superintend the curing.

I find that the beans were very good indeed. Sample B was the better of the two and was equal to any Mexican that I have ever seen, both in general appearance and especially in the high quality of the extract obtained from them. Sample A was about equal to the second grade Mexicans. It had a rank odor and taste that made it unsuited for the finest uses.

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[1] Letters refer to samples cured by different processes.

I took the liberty to take these beans and the extracts made from part of them to the Flavoring Extract Manufacturers' Association's convention in Chicago and found the convention highly interested in them. It was their opinion that "Grade B" was very fine and "Grade A" a good second-class bean.

These reports indicate both the good quality of vanilla produced in Porto Rico and a ready market for it.

The 1917 crop was picked from September 14, 1917, to January 21, 1918. It was the yield from a tenth-acre plat on which 42 plants, or seven-ninths of the total, were in production, the others either not fruiting or having been excluded from the recorded yield as diseased. The dried beans as marketed occupied a trifle less than 1 cubic foot of space, weighed 36.44 pounds, and were sold in New York at $3 per pound, producing a gross return of $109.31. Though $3 a pound was offered by two firms a number of offers were only around $2. This crop is shown in Plate I and is discussed in the following pages.

Prospective planters, in considering the returns obtained by this station and the returns which they themselves may obtain, should remember that Porto Rican vanilla is a new crop which has not as yet established for itself a place in the markets, and with its quality not generally known certain difficulties in marketing may be expected to present themselves to pioneers.

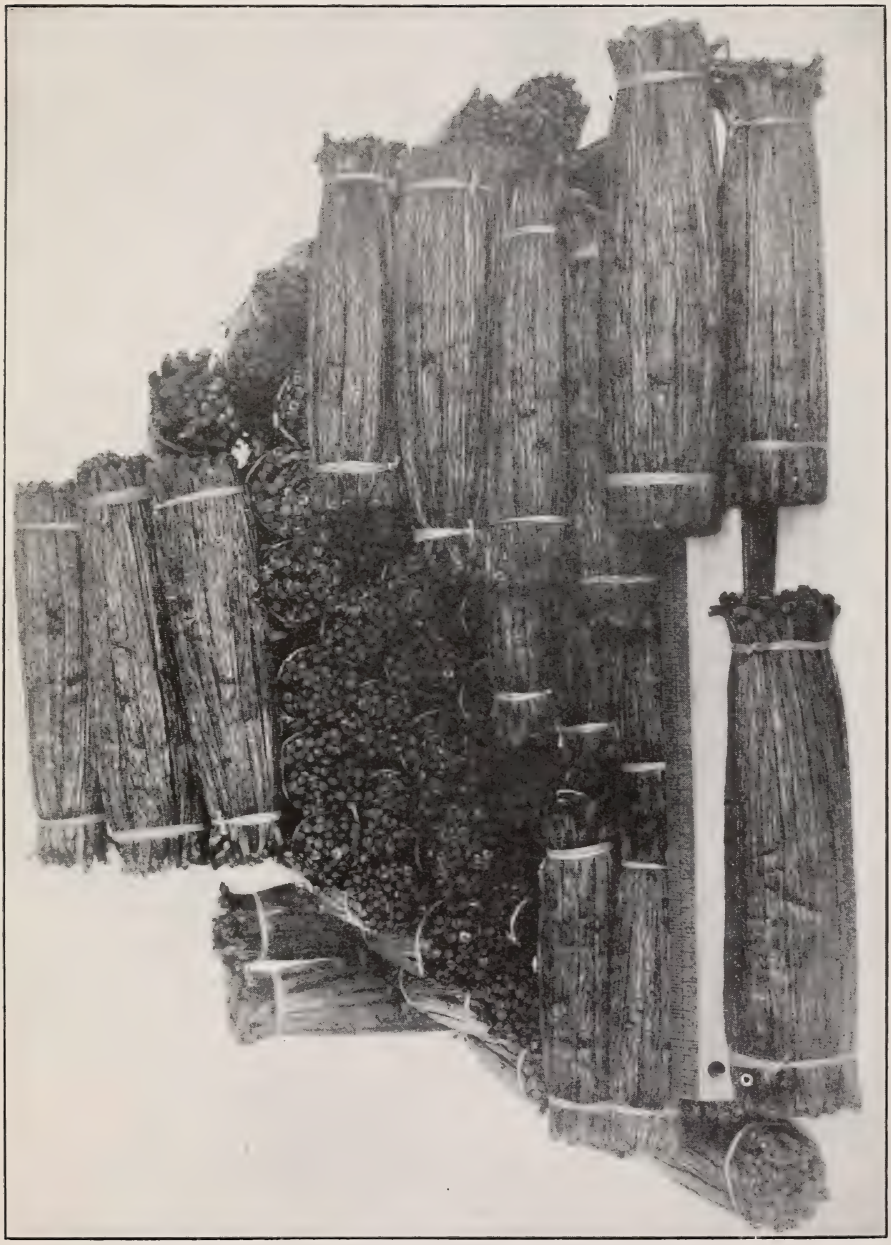
STARTING A VANILLERY.

In selecting a site for a vanillery, several things are to be desired, such as a loamy soil, abundant humus, not too steep a slope, and protection from strong winds.

While vanilla can be made to thrive on almost any soil by the addition of plenty of decaying vegetable matter, if the mechanical condition of the soil is such that it can be easily penetrated by the coarse succulent roots of the vanilla, so much the better. Such soils, though not common, are to be found in various parts of the island. One type occasionally seen in the interior which would seem admirably adapted is full of numerous small stones and so friable that it easily crumbles underfoot.

If the land slopes steeply it should unquestionably be terraced. As little can be done to the land after the vanillery is established except to clean it and add humus-forming materials, terracing should be done before the vanilla is set. A leaf mulch is very important, and, as in both pollinating and harvesting the crop the vines will have to be gone over frequently, unless the land is terraced this repeated walking around the vines will make the maintenance of a mulch very difficult on any but flat or gently sloping land.

The succulent, tender, heavy, pendent growth of the vines lays them open to damage from strong winds. In most locations, the supporting tree will furnish sufficient protection against the wind,



VANILLA BEANS PRODUCED ON ONE-TENTH ACRE AND SOLD FOR $109.31.

FIG. 1.—VANILLA ON DWARF BUCARE.

FIG. 2.—VANILLA GROWING IN FULL SUNLIGHT.

but in badly exposed places this should be supplemented by a special windbreak on the windward side.

While vanilla can be planted on scattered trees just as they are found, it is a crop which requires so much attention that everything to simplify and systematize the necessary labor should be done. Work is greatly facilitated by planting in as regular order as the conformation of the site permits. On sloping land the rows should follow the contour lines of the slope. The ground should be cleared of all trees and undergrowth and then systematically staked off and planted with the trees which are to serve as supports for the vines. Posts can be used, but they are not satisfactory as they are soon destroyed by white ants or decay. A tree suitable for carrying vanilla must branch sufficiently low for the vines hung over its branches to be within easy reach. It should also be of rapid growth and easily propagated. The dwarf, red-seeded bucare (*Erythrina corallodendron*) has proved well adapted for this purpose. Its low-branching habit and rapid growth in full sunlight commend it. In shade its development is less rapid. In good soil it requires frequent prunings to prevent its shade from becoming too dense, but the growth which is superfluous as shade serves a useful purpose in providing material for mulching the vanilla roots. It is preferable for the supports to be planted a year prior to setting the vanilla cuttings, but both can be planted simultaneously when an earlier planting of shade is impracticable.

Many different spacings are in use. The vines in the older station vanillery (Pl. II, fig. 1) were set 9 by 9 feet. This furnishes an ample area for root extension. Though the maximum root extension measured in the station vanillery has been to a distance of 5 feet from the base of the support, the roots rarely extend so far. Wide spacing, however, simplifies the removal of diseased plants without disturbing near-by healthy ones and should retard the spread of root disease. It has given very satisfactory results in the station planting. A newer planting has been made with the vines set 5 feet apart in rows 10 feet apart. This wide spacing between the rows facilitates the bringing in of manure or leaf mulch and would perhaps prove preferable to others for terraced plantings on steep slopes. Some practical growers elsewhere plant their vanilla 4 by 8 feet. These three spacings give 537, 871, and 1,361 vines, respectively, per acre. As a vanilla vine with roots starting from many points somewhat resembles a colony which may make unlimited development under favorable conditions, the same hard and fast rules for spacing can not be laid down as for plants which are strictly individuals and for whose best development a more or less known amount of space is requisite and beyond which they will not develop. Closer plantings mean larger

early returns, but the spacing should not be too close for the convenience of the workers.

A very practical beginning for establishing clean cultivation in the site selected for the vanillery is to plant cuttings of dwarf bucare (*Erythrina corallodendron*) 3 or 4 feet in length and about 2 inches in diameter considerably closer than those required for supporting the vanilla a year or more in advance of planting the vanilla. A planting at the station spaced 5 by 5 feet has made so dense a shade in 15 months that almost no weeds would grow under it. The very few weeds which can survive this heavy shade are easily cleaned out. Then at setting the vanilla the shade trees can be thinned to a desirable degree furnishing mingled sunlight and shade. All superfluous growth should be cut up and piled at the base of the supporting trees to furnish a mulch for the vanilla roots. Stock are fond of the leaves of the dwarf bucare and must be kept off the land from the time of planting the supports for the vines.

PROPAGATION.

Vanilla is propagated by means of cuttings. These should be taken from the most vigorously growing vines available.

Short v. long cuttings.—The length of the cutting has a very pronounced influence on the development of the vine. To ascertain this effect the following experiment was undertaken:

Eighty cuttings were made in four groups, respectively, of 2, 4, 8, and 12 internodal lengths of vine, no tender tips being used. Planting conditions of soil, leaf mulch, and light were uniform for the four groups. The growth of this planting is shown in the following table, with a graphic representation in figure 2.

Effect of length of cutting on growth of vanilla vines.

Length of cuttings.	Number of cuttings starting growth in—		Length of total new vine at 4 months after planting.	Number of vines having 5 feet of new growth at 5 months after planting.	Average new growth of vine per plant at 12 months after planting.
	Three months.	Six months.			
			Inches.		*Feet.*
2 internodes	3	16	31	1	4.7
4 internodes	10	19	102	5	7.7
8 internodes	11	19	216	10	10.7
12 internodes	16	20	499	18	16.7

In the group of shortest cuttings, two of which remained alive through the first year failed to start any growth of vine in this time, but one of these started growing at a little more than 15 months after planting. Of each of the next two lengths, one cutting died without

starting vine growth. In calculating the average growth for the year these four were omitted. The relative growth of new vine at 4 months from planting bore an interesting relation to the length of the cutting, as the growth of each group more than doubled that made by

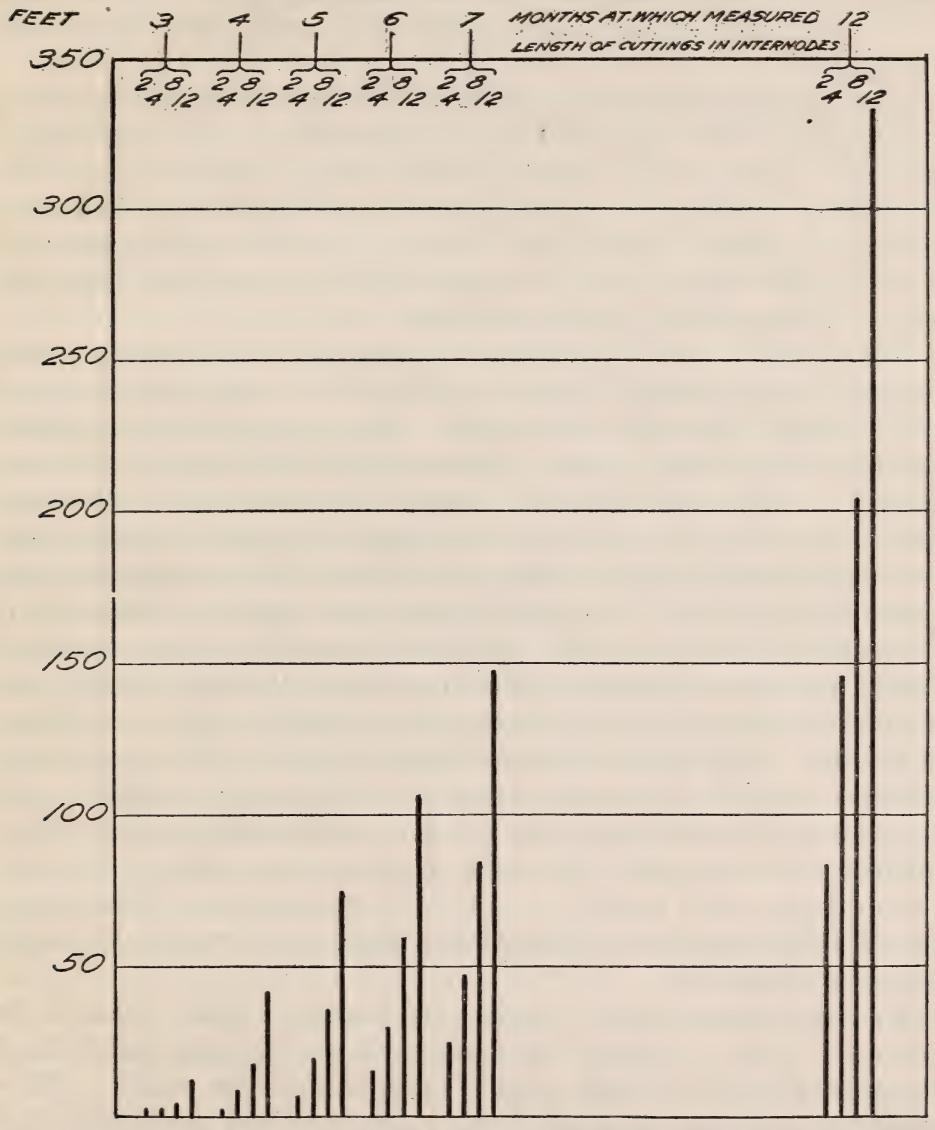


FIG. 2.—Growth made by four groups, each of 20 vanilla cuttings, of 2, 4, 8, and 12 internodal lengths, respectively.

the group of cuttings of the next shorter length. The measurements at the end of 12 months showed that where cuttings of 3 to 13 nodes are used, every advantage is with the longest cuttings.

In the blossoming season of the year following planting, at about 16 months, three plants of the group of longest cuttings flowered, but no others. This indicates that in propagating vanilla long cuttings are also preferable to short ones because they bring the vines into earlier production.

Another test was made in which 10 cuttings each of 12, 18, and 24 internodal lengths were planted. A fungus in the leaf mulch destroyed a part of the covered stem of all but 3 of each length. The latter made an average growth of 61, 60, and 76 inches per vine, respectively, in the first 5 months after planting, showing the cuttings of 24 internodal lengths to have grown more rapidly than the shorter cuttings.

Long cuttings should always be used, provided material for planting is abundant. However, where this is available in only a very limited amount, it might be advisable to use short cuttings in order to establish a vanillery more quickly, as the growth made by the shorter cuttings is greater in proportion to the length of the cutting than that made by the longer ones, but short cuttings should be used only because of scarcity of planting material.

Soil-covered v. surface planting of cuttings.—In planting vanilla cuttings, the generally accepted method is to cover several of the lower nodes with soil or leaf mold. The experience of the writer has been that while in many instances no bad results have been observed to follow this practice, at other times the entire covered portion of the cutting has rotted, even though no break or injury was to be found in this part, the two uncovered ends of the cutting remaining green and unrotted. So much rotting and disease of one kind or another has been observed to originate in a covered-over portion of vanilla stem that after the cutting has been established the layering of additional runners should always be avoided as a potential source of trouble. A correspondent from Dominica writes that the Reunion practice, which is to lay the cutting into the ground an inch or two deep for a foot of length, will not do for Dominica on account of rotting. Instead, the vine is laid on the surface, secured with two crotched pegs, and merely covered with wilted grass. The trouble with rotting arises from placing below the surface what is by nature an aerial organ only.

To test propagating by leaving the cutting entirely clear of the ground, 12 tip cuttings of 10 nodes each were simply tied to their supports with the bottom node 2 inches above the mulch. Roots pushed out at approximately 5, 8, 11, 12, 15, 16, 18 (on two), and 20 weeks, respectively, on nine cuttings; while at 27 weeks, at which time the final data presented were taken, three had still developed no roots. On seven of the rooted cuttings the root developed from the bottom node, on one instance being supplemented by an additional root from the third node; on the other two cuttings it sprang from the second node. As aerially developed roots do not always travel directly toward the ground, but sometimes strike out at a considerable angle from the perpendicular, they require a variable length of time in which to reach the mulch. In most of the above

instances this was about two weeks, the mulch having settled 3 to 4 inches below the bottom node. At 14 weeks no new vine growth had started, but at 15 and 16 weeks the two earliest rooted cuttings had started growth, followed by two at 21, two at 24, one at 25, and one at 26 weeks. At 27 weeks one rooted cutting had as yet failed to start new vine growth.

Simultaneously with the preceding test 18 additional cuttings made January 3 were tied high above the ground against upright slats to to watch the root development in air of cuttings of different lengths, there being six cuttings of 5, 10, and 15 nodes each. In the first seven weeks there was no root development, but in the eighth week one of the long and two of the medium cuttings pushed out a root from the bottom node. At 24 weeks the former had lengthened to 26 inches and the two latter to 27 and 31 inches. Measurements taken weekly showed the weekly increase in root length to vary from nothing to more than 4 inches. Due to the greater rainfall in the latter part of this period the air was much more moisture-laden than in the earlier part, and the root growth was much more rapid, approximately three-quarters of the increase in length being made in the last seven weeks in two of the three preceding cases. In the seventeenth week another medium-length cutting started a root, followed by two of the short cuttings in the twenty-first week. At approximately these same dates, judging from their development when first seen, two of the longest cuttings started roots, one from the sixth and ninth nodes up and the other from the top node. In the 24 weeks during which these cuttings were under observation, half of the long, half of the medium, and two-thirds of the short cuttings failed to develop roots. Those cuttings which developed roots became wrinkled and shriveled as the root lengthened, while the others remained plump, and all remained green.

In each of the two preceding tests, half of the cuttings had the lower nodes protected from the light by wrapping in a yautia leaf, which afforded shade until it rotted some weeks later, but no effect on root development was seen from shading these nodes.

Where a piece of vine has been cut away, leaving a section high in a tree and entirely unconnected with the ground, a root is sometimes seen to have been sent down for a number of feet, even traveling a greater distance than the length of the cutting from which it sprang, in order to reestablish connection with the ground. This aerial development of root shows that vanilla cuttings need not necessarily be planted in a medium of soil or mulch, but may simply be tied to their supports. The records of root development on cuttings so placed show, however, that the development of the cutting under this system is very much retarded.

A test was made in order to investigate several points in the ordinary manner of planting, as whether or not the basal tip should be left exposed when several nodes above it have been covered, whether the cuttings make better growth in soil or leaf mold, and whether they should be taken some days before planting and allowed to wilt or planted immediately. Forty-eight tip cuttings of 10 nodes each were taken on the same day. Half of these were planted immediately, while the others were spread in a fairly well shaded place and allowed to wilt for 12 days before planting. Twelve-inch pots were used, three cuttings being set in each pot, with two or three nodes of each cutting covered. Eight pots were filled with leaf mold and forest trash collected from an old coffee plantation, the other eight being filled with a soil mixture of river sand and clay in equal parts. The pots were supplied with uniform amounts of water.

Covered v. projecting basal tip.—The recommendation has been made [1] that, in planting, the lower tip of the cutting be left projecting above the ground, as when this is covered decay frequently sets in, travels along the stem, and prevents the formation of strong roots on the part of the cutting below ground. To test this, 24 cuttings were planted with the basal tip covered and 24 with the tip projecting into the air. In the table below results are not given with reference to this point, as no rotting from covering the bottom end of the cutting was observed. Allowing the basal tip to project in the air is considered an expedient planting practice, however, since, as even a sound stem in the ground or in the mulch is very susceptible to disease, a cut surface would appear an even more likely means of entrance to organisms which produce decay.

Leaf mold v. soil for planting.—The roots were very carefully removed from the pots and their length measured to a quarter of an inch. The results are shown in the following table:

Comparative growth of wilted vanilla cuttings and those planted immediately in soil and in leaf mold.

	Number of roots or root branches on six cuttings.		Length of root growth made by six cuttings.		Length of new vine growth made by six cuttings.	
	Soil.	Leaf mold.	Soil.	Leaf mold.	Soil.	Leaf mold.
Cuttings planted immediately:			*Inches.*	*Inches.*	*Inches.*	*Inches.*
61 days after planting	162	225	314	635¼	10	22
73 days after planting	231	279	600½	1,080¾	28	56
Cuttings wilted 12 days:						
49 days after planting	123	181	192¾	389½	9	13
61 days after planting	219	227	452½	782	34	30
Total for 24 cuttings	735	912	1,559¾	2,887¾	81	121

[1] Vanilla cuttings. Agr. News Barbados, 14 (1915), No. 333, p. 41.

The measurements of root development show this to have been 85 per cent greater in leaf mold than in soil. The new vine growth was also considerably greater for the leaf mold than for the soil. This clearly indicates the importance of keeping the vines supplied with a heavy leaf mulch.

Wilting v. immediate planting of cuttings.—Some advise wilting the cuttings 12 or 14 days before planting.[1] In the test of this point, which is summarized in the table above, the cuttings which were wilted for 12 days previous to planting fell far behind cuttings made simultaneously with them and planted immediately. However, when the wilted cuttings were measured 12 days later than those made simultaneously with them and set immediately, both thus remaining planted for an equal period of time, the growth made by the wilted cuttings exceeded that made by those which had been planted immediately. As the growth under both systems was very satisfactory, it seems of little importance whether the cuttings are planted immediately or allowed to remain unplanted for a number of days, this being a point which may be left to the convenience of the planter.

Rapidity of growth of the newly planted cutting is thus seen to depend on several factors, of which the length of the cutting and the nature of the medium in which it is set are both important.

Preparation of the site for planting consists in leveling the surface of the soil around the base of the support and applying to it a heavy mulch of rotting leaves, dead grass, or forest trash.

The cuttings should be tied to the supporting tree in such a way that when new growth starts it will fasten itself to the tree or hang over a branch. It should be placed low enough for several node to lie flat on the mulch. These should be covered lightly with leaf mulch or with grass, the stem being fastened in place with a crotched stick when necessary and the basal tip left uncovered. If rotting is prevalent, the covering may be made very light and removed after the roots have started into the mulch below.

SHADING.

To test the growth of vines under varying degrees of light and shade, a planting was made of 18 eleven-node cuttings, 6 of which were in full sunlight and 12 were in four varying degrees of artificial shade furnished by a white cotton cloth, a thin unbleached cotton cloth, a heavy unbleached cotton cloth, and a thin black cotton cloth. Other conditions were made as uniform as possible and plenty of humus was supplied. From 2 to 18 months after planting monthly measurements of growth were taken, but the differences between individuals under identical conditions showed the number of plants in the tests to have been too small to show definite differences

[1] Vanilla cuttings. Agr. News Barbados, 14 (1915), No. 333, p. 41.

for each of the varying degrees of shade. At 20 months the shaded plants were put in two groups, the 6 plants which had been more lightly shaded being put under the unbleached cotton and the 6 which had been more heavily shaded under the thin black cotton. The black cotton, though faded by sun and rain and so affording varying degrees of shade, always furnished a denser shade than the unbleached cloth.

The growth made by the 18 vines in the first year averaged about 22½ feet per vine. The most heavily shaded vines made the quickest start, but their growth was much more spindling than that of the others, with frailer stems having long internodes and leaves of a darker green standing in a more nearly horizontal plane; just such growth, in fact, as may be seen on vanilla under a heavy natural shade. At a year and a half their growth averaged less than 40 feet per vine, while that of the other plants averaged 48 feet. At two years the plants in full sun had made very vigorous growth, though they were rather yellow and had suffered severely from burning on the eastern side, some stems burning in two where they bent over the support, but on the western side, which had received less sun, they continued to look very healthy and vigorous. The plants under the light shade looked best and had the largest mass of vine, while the development of those under the heavy shade was greatly retarded.

The growth of the vines indicated that while vanilla will stand plenty of light and will grow vigorously when entirely unshaded (Pl. II, fig. 2), full exposure to the sun burns the vines badly and is less favorable to their development and well-being than a light shade. The shade may easily become too dense, however, for the best development of the vanilla if pruning is neglected.

In another planting furnishing very light and very dense natural shade the heavily shaded vines showed much more spindling growth than the very lightly shaded ones.

CARE OF PLANTATION.

Both shade trees and vines need fairly frequent attention. If the soil is good, such supporting trees as *Erythrina corallodendron*, necessarily closely set to furnish sufficient supports for the vines, will form a shade much too dense for the best development of the vanilla unless given frequent prunings. In pruning the shade, if alternate trees rather than all trees are pruned each time, the danger of injury to the vanilla vines through a sudden change from shade to sunlight is greatly lessened. A sudden exposure to strong sunlight will burn many leaves and cause them to rot and will also burn the stems of the vines.

In pruning the shade trees, forks through which the vines may be hung should be left within easy reach of the hand, and such limbs as do not branch at this height should be cut back to force out new

branches. A broadly spread fork is most desirable. One with a narrow crotch will be likely to pinch the vine run through it as the limbs increase in size, unless a stone has been placed in the crotch below the vine. All prunings should be cut up and spread around the base of the vines as a mulch.

The value of a leaf mulch has been shown already in the much greater rapidity of vanilla root growth in rotting leaves than in soil. The coarse, easily cut roots feeding at or very near the surface make any cultivation out of the question. What can be done is to provide the vines with plenty of humus-forming materials, such as forest sweepings, cane trash, or old well-rotted strawy manure, in addition to the prunings from the shade trees. Where such material is not abundant, plantings of a Stizolobium or other cover crop may be made nearby and the growth cut and carried into the vanillery.

Weeds should never be hoed near the plants, but should be pulled up by hand. Hoes and machetes should be used only on the land which is midway between the plants and thus not occupied by the vanilla roots.

The rapid growth of the vines, the necessity of keeping them within easy reach for pollination of the blossoms, and their succulent and rather brittle nature all combine to demand constant attention from the planter. Several different systems of pruning or training the vines are being tested, but as yet only rather general recommendations can be given. A vigorously growing runner will lengthen 2 to 2½ feet in a month's time. For easy handling of the new growth, the vines should be gone over every six or eight weeks. If this is done only at long intervals, the runners climb high in the trees and are difficult to get down and easily damaged in the process, as a new bend in a heavy vine is apt to cause it to snap in two.

The essential point is to keep the vine always within easy reach. After ascending to a height of 5 or 6 feet, it should be bent over a branch and allowed to hang down until it reaches almost to the ground. A young vine, or one which has not some growth through all the well-located forks of the tree, should be allowed after it has reached almost to the ground to reascend the support. To accomplish this, the runner should be tied to the support at about 6 inches above the ground. Raffia is excellent for tying the vine. Other pendent vines may have their tips pinched off at about this same distance above the ground. Just what proportion of the runners should be allowed to reascend the support and what proportion should be pinched back before reaching the ground has not been determined. Those whose further elongation has been stopped offer an advantage not possessed by the others in that after they have fruited the then useless portion of vine may be cut away without damaging the rest.

After cropping, it is well to remove and destroy such checked portions of vine as have fruited at nearly all nodes. Of course, where the fruiting portion of the stem is a section of a long runner which has reascended the support, the cutting away of the part which has fruited would be inadvisable, as it would reduce the growth made beyond that point to the condition of a cutting.

BLOSSOMING AND POLLINATION.

Effect of length of cutting on blossoming.—In the experimental planting (set in February and reported on p. 10) of 80 cuttings ranging in length from 2 to 12 internodal lengths, 3 of the 16 longest cuttings flowered in June of the following year, while none of the others flowered that season. This indicated that longer cuttings may be expected to blossom sooner than shorter ones. A long, vigorous cutting may blossom at a year from setting. In another planting of 55 cuttings of 11 nodes each, 23 plants, or 42 per cent, blossomed in the second blossoming season, a little more than a year and a half after setting. As planting material was scarce when the earlier plantings were made at the station, many of the plants were propagated from cuttings much too short for rapid early development, and so where longer cuttings are used earlier flowering should be expected than was had in the following plantings. Of 52 plants from cuttings of miscellaneous lengths, not included in those mentioned above, 9 plants, or 17 per cent, blossomed in the second blossoming season after setting; of 48 plants, 28, or more than 58 per cent, blossomed in the third blossoming season; while all healthy plants under observation blossomed in the fourth, fifth, and sixth seasons, the record to date.

The blossoming period.—The blossoming season extends over a protracted period, a fortunate circumstance, since hand-pollination must be resorted to.

A record for three seasons of the date of opening of the first blossom of the season on each of a number of plants showed this to have been in January in 4, in February in 19, in March in 41, in April in 14, in May in 4, and in June in 2 instances.

The following table shows the average blossoming period for 10 plants to have extended over nearly 8 weeks:

Duration of blossoming season for 10 plants.

Plant No.	Date of opening.		Duration of blossoming season.	Plant No.	Date of opening.		Duration of blossoming season.
	First blossom.	Last blossom.			First blossom.	Last blossom.	
			Days.				*Days.*
1	Mar. 26	May 7	43	7	Apr. 11	May 27	47
2	Mar. 28	May 14	48	8	Apr. 14	June 8	55
3	Mar. 30	June 3	66	9	Apr. 16	June 15	61
4	Apr. 2	May 15	44	10	Apr. 17	May 29	43
5	do	June 3	63				
6	Apr. 3	June 1	60		Average for 10 plants		53.1

Since March is the month in which the greatest number of plants begin to blossom and since the blossoming period for a single plant may extend over a couple of months, plantings in the vicinity of Mayaguez will need labor for pollination chiefly in March and April but possibly for a longer period.

The following table gives the record of the blossoming performance of eight typical clusters on a single plant, not the entire blossoming of that plant:

Blossoming record of eight clusters of vanilla blossoms.[1]

	Cluster—							
	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No. 6.	No. 7.	No. 8.
Mar. 24					x			
Mar. 25								
Mar. 26							x	
Mar. 27					x			
Mar. 28		x		x		x		
Mar. 29					x		x	
Mar. 30		x			x			
Mar. 31	x		x			x		x
Apr. 1	x				x		x	
Apr. 2		x			x	x	x	x
Apr. 3		x		xx			x	
Apr. 4	x				x	x		
Apr. 5	x	x		x	x	x	x	x
Apr. 6		xx		x	x			x
Apr. 7						x	x	
Apr. 8	x		x		x	x	x	x
Apr. 9	x	x		x	x	x		x
Apr. 10	x		x				xx	x
Apr. 11	x	x		x	x	x		
Apr. 12		x	x		x	x	x	x
Apr. 13	x		x	x				
Apr. 14	x				x	x	x	x
Apr. 15		x	x	x				x
Apr. 16	x	x		x	x	x	x	x
Apr. 17	x				x	x		x
Apr. 18							x	
Apr. 19		x		x		x	x	x
Apr. 20	x				x			x
Apr. 21						x	x	
Apr. 22								
Apr. 23							x	x
Apr. 24								x
Apr. 25								x
Apr. 26								x
Apr. 27								
Apr. 28								x
Apr. 29								
Apr. 30								x
Number of days on which blossoms opened	13	12	6	10	17	15	16	20
Number of intervening days on which no blossoms opened	8	11	10	13	11	10	13	11
Number of days between the opening of the first and final blossom	21	23	16	23	28	25	29	31

[1] x represents a blossom.

The above record is no way extraordinary, as clusters could have been selected which in both number of blossoms and time covered considerably exceeded any given here. These clusters averaged 14 blossoms each, opening in 13.6 days, with 10.9 days on which no blossoms opened intervening between the opening of the first and the final blossom for the average cluster, a period of 24.5 days. The erratic manner of blossoming is shown by a cluster opening two blos-

soms on the same day, or single blossoms on two, three, or four successive days, or with an interval of from a day to a week between blossoms. Only very rarely do as many as three blossoms of a single cluster open on the same day.

On mature vines blossoms have been noted in the spring from growth made as late as the preceding October.

Four inflorescences, the buds of which were noted as pushing out on December 29, opened their first blossoms February 23, 25, 26, and 28, while of six others breaking through on January 4, two opened their first blossoms on March 5, two on March 7, and the others on March 9 and 12. This showed a period of approximately two months to elapse between the pushing out of the inflorescence bud and the opening of the first blossom.

Description of blossoms.—The flowers are borne in a spike or raceme sometimes branching and forming a panicle. The inflorescence is centripetal and usually axillary, but occasionally it terminates a long stem. The waxen, pale-green blossom is borne at the apex of the ovary, which is 4 to 5½ centimeters long at blossoming. This is subtended by an ovate bract about 5 millimeters long and 4 millimeters broad at the base. The five spreading segments of the perianth are rather similar, 6 to 6½ centimeters long, 1.3 to 1.5 centimeters broad, unsymmetrical, elliptical-spatulate, and not much recurved. The midrib at the back of the two petals is about 3 millimeters shorter than the petal, its tip not adnate for 1 to 2 millimeters and recurved. The trumpet-shaped labellum, or lip, which is united with the column, is about 5 centimeters long and 1.5 centimeters in diameter. The disk of the lip is yellowish-green and verrucose, with a central crest or tuft facing the essential organs. The margin of the lip is unevenly dentate. The column is about 5 centimeters long. (See Pl. III, fig. 1.)

Hand-pollination.—In order that the explanation of the steps in hand-pollination may be more readily understood, in Plate III, figure 2, a cleared and magnified column [1] is shown in progressive stages of pollination, beginning with the organs untouched at the left and showing the pollination completed at the right. At the apex of the column hangs the anther bending over the stigma, which consists of a large single lobe representing one carpel and two smaller united lobes representing two carpels. The large lobe covers the smaller ones and protrudes beyond them. As its dorsal surface is toward the anther, pollen is effectually prevented from reaching the stigma without outside aid. The bristly crest or tuft within the lip and opposite the essential organs is the provision for inducing departing insect visitors to cross the stigma and anther and so deposit and collect pollen, but as the vanilla blossom does not attract insect visitors, hand-pollination must be resorted to.

[1] Of a species with larger blossom than *V. planifolia*.

FIG. 1.—FLOWERS OF VANILLA PLANIFOLIA.

FIG. 2.—COLUMN OF VANILLA SP. SHOWING STAGES IN POLLINATION.

In such instances as have been noted in which the blossom has been fertilized with pollen taken from the blossom of another plant of the same species, no noticeable difference has been observed between the development of the resultant pods and those from close-fertilized blossoms. The pollen mass is easily dropped, and the use of pollen from a different blossom would greatly complicate and retard hand-pollination.

A small splinter of bamboo, a stem of stiff grass, or a sharpened match or toothpick is a satisfactory implement for the pollinator. The lip of the blossom is torn down with the thumb, and the index finger of the left hand is placed behind the tip of the column, with the other fingers back of the flower, steadying it. With the splinter held in the right hand, the large lobe of the stigma is lifted and pressed into the cavity back of the anther and held there by the thumb of the left hand placed lightly above and to the left of the pollen sac, while the point of the splinter is gently pressed against the pollen sac to force the pollen out upon the stigma. With a slight upward pressure of the splinter as it is removed the anther rises and the large lobe of the stigma descends to the original position, shutting in the pollen mass between the lobes of the stigma.

Hand-pollination is a quick and easy process and should be done by women and children to whom heavier work is less suited. The writer, working steadily for an hour, pollinated 237 blossoms, or at the rate of about 4 a minute. This did not allow time for the proper selection of blossoms, since many through their position are undesirable. The most desirably placed blossom is one whose ovary, the small green pod resembling a flower stalk, is attached to the lower side of the inflorescence stalk and will later hang perpendicularly toward the ground, forming a perfectly straight pod. Those attached to the upper side should be left unpollinated, as they will form very crooked pods, which will be difficult to bundle and present in an attractive and easily handled form.

Tests of different hours of the day for pollination.—Contrary to the behavior of most orchids whose unpollinated blossoms remain fresh for days and even weeks, the vanilla blossom begins to close early in the afternoon of the same day on which it opens and by the next morning it has withered. This early closing and brief existence of the blossom made it desirable to find whether pollination should be practiced in only certain hours of the day. The failure or success of pollination is indicated by the early dropping of the blossom from the ovary, to which, on the other hand, if fertilization has taken place, the column clings for an indefinite period, sometimes even until the pod is sufficiently mature for picking. Of 200 blossoms hand-pollinated at intervals from 8.15 a. m. to 5 p. m., only 15 dropped within one week of opening, but their dropping showed no relation to the hour of pollination. In addition, blossoms were

successfully pollinated both before daylight and after nightfall, artificial light having to be used to enable the pollinator to see in each instance. The results of the test indicate that pollination may be begun as early and continued as late as is convenient, the hour of pollination having no effect on the number of pods setting, but as the sepals and petals begin to close around the lip in the early afternoon, the morning hours permit easier and more rapid work than the afternoon, and for this reason work should be begun as early as possible.

Forty blossoms pollinated in the late afternoon after a rain all set, showing that a rain prior to pollination need do no damage since the essential organs are well protected by the lip.

Comparative dropping of hand-pollinated blossoms and those not hand-pollinated.—The 200 blossoms of the above test were compared with 200 which were not hand-pollinated, with the result that 92.5 per cent of the hand-pollinated blossoms remained clinging to the ovary after an interval of one week, while only 1.5 per cent of those not hand-pollinated remained. No blossoms of either lot had dropped by 4.30 p. m. of the day following opening, but of all blossoms which dropped within a week of opening more than 94 per cent had dropped by noon and nearly 98 per cent by 4.30 p. m. of the second day following the opening of the blossom. The pollinator thus sees within a few days after pollinating just which pods have set and so is enabled to discontinue pollinating as soon as the desired number has been obtained, there being practically no chance fertilization.

Pollination of early opening v. late opening blossoms of a cluster.—To determine whether the earlier opening blossoms of a cluster possess an advantage over those which open later, measurements were taken of the length of the pods in 100 clusters which had developed two pods each. In 57 instances the longer pod had developed from the earlier blossom, in 8 the pods were of the same length, and in 35 the longer pod had developed from the later blossom.

Heavy v. light pollination.—With few crops is the grower able to definitely determine the size of his harvests. Yet within certain limits this is true of the vanilla grower. As the vanilla vine produces a much greater number of blossoms than it is able to develop pods, it lies with the pollinator to say how many pods shall be produced. With the object of determining something of the effect on the size of the pods of heavy and light pollinations, the following experiment was undertaken with the 1917 crop in the station vanillery:

As the plants differed in amount of vine growth, the production of a definite number of pods per plant would have imposed a very uneven demand on the different plants since what for some would have constituted a yield of reasonable quantity for others would

have been entirely too heavy or entirely too light a production. It was thought that the nearest approximation to the proportional ability of the different plants for fruiting was indicated by the number of flower clusters produced. The plants in the vanillery were classified in three groups in which accordingly 2, 4, and 6 pods respectively per cluster were allowed to develop. Each group is designated by the corresponding numeral 2, 4, or 6. The groups were made up of plants in alternating rows to insure as uniform a distribution as possible. As in some instances the clusters failed to produce the requisite number of blossoms or the pods failed to set, the average number of pods produced per cluster was slightly below 2, 4, and 6 pods, respectively. The actual production of pods per plant was in the ratio of 2, 3.4, and 5.4 for the three groups. Had the number of plants in the test been greater the ratio of pods per plant would have more closely followed that of pods per cluster.

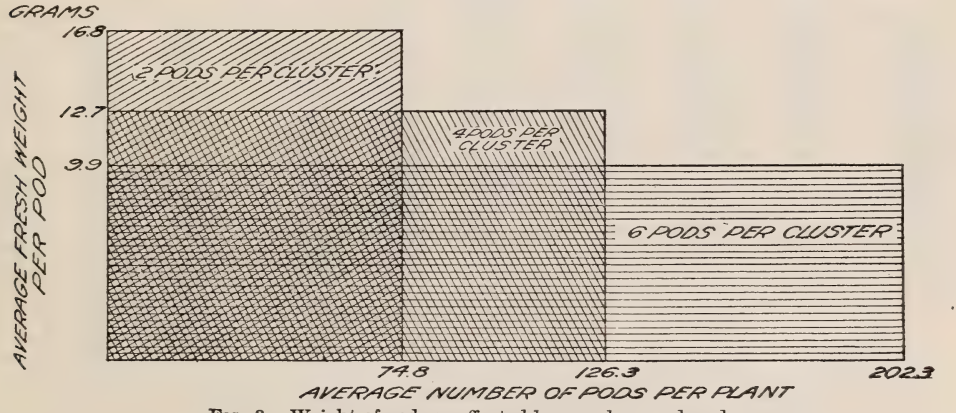


FIG. 3.—Weight of pods as affected by number produced.

In figure 3 the average number of pods and average weight per pod are shown graphically for the three groups. In the table following, the production of the individual plants is given.

Yield and size of pods of 1917 crop of vanilla.

GROUP 2.

Plant No.	Year of planting.	Number of pods per plant.	Fresh weight of pods per plant.	Average fresh weight per pod.
			Grams.	*Grams.*
15	1915	22	413	18.8
136	1913	40	642	16.1
16	1912	40	710	17.8
137	1913	49	797	16.2
107	1913	62	971	15.7
45	1912	65	1,241	19.1
105	1913	70	1,112	15.9
77	1912	74	1,303	17.6
78	1912	80	1,397	17.5
108	1913	84	1,452	17.3
47	1914	85	1,552	18.2
135	1913	89	1,176	13.2
75	[1] 1914	90	1,457	16.2
46	1912	109	1,971	18.1
106	1913	163	2,704	16.6
Total		1,122	18,898	
Average		74.8	1,260	16.8

[1] Set in 1912 but almost totally destroyed by falling tree in 1914, so considered as of latter year.

Yield and size of pods of 1917 crop of vanilla—Continued.

GROUP 4.

Plant No.	Year of planting.	Number of pods per plant.	Fresh weight of pods per plant.	Average fresh weight per pod.
			Grams.	*Grams.*
87	1913	33	611	18.5
26	1912	36	665	18.5
88	1914	52	716	13.8
86	1913	54	759	14.1
118	1913	96	1,282	13.4
115	1914	100	1,147	11.5
146	1914	100	1,401	14.0
25	1912	122	1,877	15.4
56	1912	127	1,893	14.9
85	1913	130	1,443	11.1
116	1913	243	2,793	11.5
57	1912	422	4,694	11.1
Total		1,515	19,281	
Average		126.3	1,607	12.7

GROUP 6.

128	1913	11	188	17.1
158	1914	29	342	11.8
155	1913	65	881	13.6
98	1913	69	883	12.8
126	1914	74	881	11.9
129	1913	94	1,252	13.3
36	1912	124	1,853	14.9
35	1912	127	1,602	12.6
125	1913	152	1,471	9.7
97	1913	222	2,494	11.2
96	1913	226	2,137	9.5
67	1912	312	3,096	9.9
95	1913	319	3,256	10.2
66	1912	500	4,640	9.3
65	1912	710	5,085	7.2
Total		3,034	30,061	
Average		202.3	2,004	9.9

In considering the average fresh weight per pod in no instance did that of a single plant in group 2 fall as low as the general average for group 4, or that of a single plant of group 4 fall as low as the general average for group 6. If from group 4, plants Nos. 87 and 26 might be excluded on account of the small number of pods produced (less than half the average for group 2) and from group 6 plant No. 128 with only 11 pods, then with one exception every plant in group 2 ranked ahead of the highest in either group 4 or 6. With one exception the produce of every plant of group 2 averaged well in weight per pod, whereas in groups 4 and 6 the production of 130 pods and over, in some instances even less, was accompanied by a greatly reduced average weight per pod. With the production of an increased number of pods, as shown by the averages for the three groups, there resulted a decrease in weight per pod and consequently in value per pound, the larger pods being more valuable, but there was an increase in weight of the total production.

The length of each pod was measured to a quarter of an inch. The average production of pods of each length for the three groups is shown in figure 4 by the distance on any horizontal between two verticals of the same group.

The following table gives the number of pods of each length produced by the average vine of each group, and the equivalent percentages for the same:

Relation between length and number of vanilla pods in average production per vine.

Length of pods.	Group 2. (74.8 pods per vine).		Group 4. (126.3 pods per vine).		Group 6. (202.3 pods per vine).	
	Average number of pods per vine.	Percentage of total production.	Average number of pods per vine.	Percentage of total production.	Average number of pods per vine.	Percentage of total production.
4 inches	1.47	1.96	2.42	1.91	10.87	5.37
4 inches	.67	.89	3.58	2.84	8.47	4.19
4½ inches	.80	1.07	2.42	1.91	6.93	3.43
4½ inches	1.33	1.78	4.25	3.37	10.27	5.08
4¾ inches	1.20	1.60	4.58	3.63	9.67	4.78
5 inches	2.47	3.30	6.42	5.08	15.07	7.45
5¼ inches	1.87	2.50	5.50	4.36	14.33	7.09
5½ inches	2.53	3.39	6.83	5.41	15.40	7.61
5¾ inches	3.80	5.08	7.67	6.07	15.60	7.71
6 inches	3.40	4.55	9.08	7.19	19.20	9.49
6¼ inches	3.80	5.08	9.00	7.13	12.93	6.39
6½ inches	5.07	6.77	11.75	9.31	13.87	6.86
6¾ inches	5.33	7.13	9.67	7.66	12.53	6.20
7 inches	7.60	10.16	11.42	9.04	13.00	6.43
7¼ inches	4.47	5.97	6.50	5.15	7.87	3.89
7½ inches	6.53	8.73	8.75	6.93	6.53	3.23
7¾ inches	6.07	8.11	6.42	5.08	4.80	2.37
8 inches	5.67	7.58	5.50	4.36	2.20	1.09
8¼ inches	4.93	6.60	2.58	2.05	1.60	.79
8½ inches	3.07	4.10	1.42	1.12	.60	.30
8¾ inches	1.73	2.32	.42	.33	.40	.20
9 inches	.73	.98	.08	.07	.07	.03
9¼ inches	.20	.27	.....	.....	.07	.03
9½ inches	.07	.09	.....	.....	.....	.....

In comparing the yield of the average plant of group 2 producing 74.8 pods with that of group 4 producing 126.3 pods, it is seen that in every length shorter than 8 inches group 4 produced a greater number of pods than group 2, while of pods 8 inches and longer group 2 produced a greater number than group 4. Of pods 8 inches in length or longer group 2 averaged per plant 16.4 pods as compared with 10 pods for group 4. Where the number of pods of each length was reduced to terms of its equivalent percentage of the total for its respective group, it is seen that the percentage of pods of 7 inches and longer in group 2 exceeded that in group 4 for every length, while with a single exception the contrary was true for all lengths shorter than 7 inches.

In comparing group 4 with group 6, the average plant of the latter producing 202.3 pods, it is seen that group 6 surpassed group 4 in number of pods for each length below 7½ inches, while group 4 surpassed group 6 for every length of 7½ inches and longer except in the single length in which group 4 produced nothing. Group 4 averaged per plant a production of 25.17 pods 7½ inches in length or longer, as against 16.27 pods of corresponding length for group 6. The percentage of pods for each length above 6 inches in group 4 exceeded that of the corresponding length in group 6 with the one

exception already noted, while the percentage of pods of 6 inches and shorter in group 4 was less than that of the corresponding length in group 6 in every instance.

These measurements show the importance of limiting the crop if a large proportion of long pods is to be had, as the number of pods produced has a direct and most pronounced effect on length of pods.

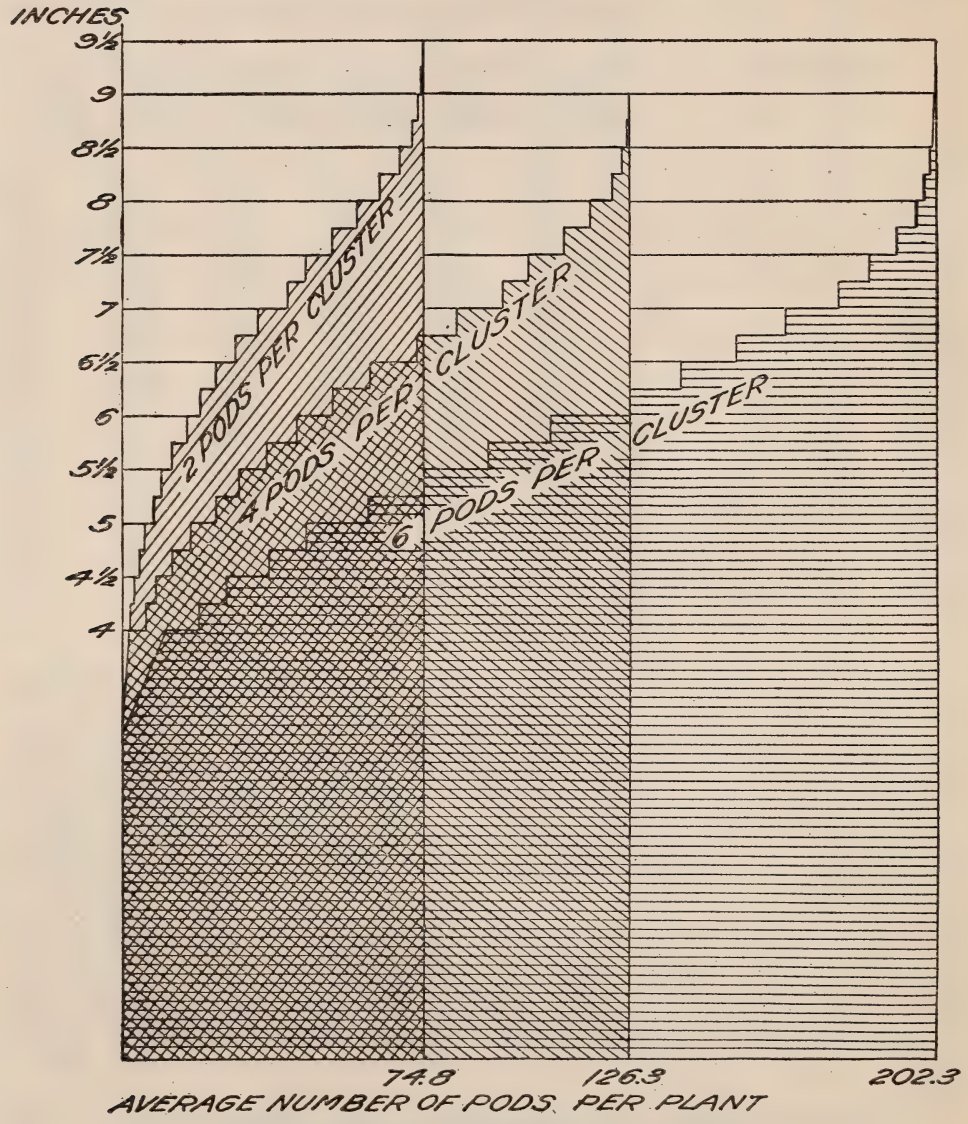


FIG. 4.—Length of pods as affected by number produced.

In the table below, which shows the weight of cured pods of different lengths, it is seen that one 8-inch pod weighs more than two 6-inch pods or three 5-inch pods. Longer pods are also worth intrinsically more than an equal weight of shorter pods, since, in addition to making a better appearance and bringing a higher price per pound, they produce an extract which, though not markedly different, is slightly superior to that from the shorter pods.[1] The number per pound was

[1] U. S. Dept. Agr., Bur. Chem. Bul. 152 (1912), p. 156.

determined by weighing from 1 to 8 bundles of each length, each bundle containing 50 beans.

Comparative weight of cured pods of different lengths from 1917 station crop.

Length of pods.	Average weight per pod.	Number of pods per pound.	Length of pods.	Average weight per pod.	Number of pods per pound.
	Grams.			*Grams.*	
4 inches	1.01	448	6½ inches	3.48	130
4¼ inches	1.16	391	6¾ inches	3.91	116
4½ inches	1.39	325	7 inches	4.03	106
4¾ inches	1.57	290	7¼ inches	4.69	97
5 inches	1.81	251	7½ inches	5.16	88
5¼ inches	2.11	215	7¾ inches	5.61	81
5½ inches	2.28	199	8 inches	6.13	74
5¾ inches	2.55	178	8¼ inches	6.81	67
6 inches	2.83	160	8½ inches	7.04	64
6¼ inches	3.14	143			

When a plant has been forced to produce an excessively large number of pods the full measure of harm of overproduction is not shown by the inferiority of the ensuing crop alone but also by the debilitated condition in which the plant is left after cropping, with its consequent effect on following crops.

It is then seen to rest with the pollinator within certain limits to determine whether the crop shall be of numerous or of few, of short or of long pods. In order to avoid the pollination of too many blossoms, the loss of the plants' vitality in the production of useless blossoms, and also the loss of the pollinator's time in the frequent examination of superfluous blossoms, it is advisable to go over the vines at short intervals during the blossoming season, clipping the stalk of the inflorescence just back of the remaining buds, or clipping the buds themselves on such clusters as have the desired number of pods already set, and removing any undesirable pods. A suitable implement for doing this is a pair of blunt shears such as orange pickers use.

When fertilization has occurred the pod elongates at a rapid rate, its length increasing in some instances more than an inch a week. Full length is attained in 6 to 8 weeks.

PICKING.

The pods are not allowed to mature fully on the vines, as they do not mature simultaneously throughout their length, the apex turning yellow and splitting open while the base is still green. Split pods are looked upon with disfavor by buyers. The pod should be picked just before reaching the stage at which it would split if left on the vine, a condition usually indicated by a slight yellowing near the apex or by the pod first becoming oily and later yellow in appearance. To attain this degree of maturity requires anywhere from 7 to 9 months, or even a little longer. The time or order of maturing is not in strict

accord with the opening of the blossoms, as the following instances show: In a single cluster of four pods from blossoms pollinated March 31 and April 5, 6, and 8, respectively, the earliest and the latest pollinated had split by December 26, while those of April 5 and 6 had not split. On January 7 a pod from a blossom pollinated March 28 had yellowed at the apex but had not split; of two from blossoms of March 31 one had split nearly half its length, while the other could have been left still longer on the vine without danger of splitting; and one from a blossom of April 16 had split one-fourth inch. The proper stage for picking can be learned only through observation of the appearance of pods just before splitting.

Practice is also required for skillful picking. A pod which is ready to pick can usually be removed unbroken by a sidewise pressure of the thumb placed at the base of the pod, but if the pod is twisted in removing or if the pressure is not applied directly at the base of the pod, a break is apt to result. When a small piece of the stalk comes away with the pod, it should be cut away with a sharp knife, taking care not to cut the base of the pod.

CURING.

Vanilla beans may be cured in many ways. The method followed at this station with the 1917 crop was as follows: The pods were placed in a wire basket and dipped three times in water heated to 80 to 85° C., being first immersed for 10 seconds, then for 12, and finally for 15 seconds, with 30-second intervals between dippings. While still hot, they were closely wrapped in blankets and left to sweat overnight. As the quantities dealt with were small, artificial heat was used to aid in sweating. The bundled pods, having had scalding water poured over the blankets, were put in an electric incubator set at about 43° C., but as the incubator failed to maintain a uniform temperature in accord with the regulator, this was only an approximation of the actual temperature. The following morning the pods were spread on blankets in the sun. In the afternoon they were spread on shelves in the incubator and so left until the following morning, when they were again sunned, in this and subsequent sunnings the beans being covered with a fold of blanket. This drying was continued for three or four days alternating between incubator and sun, as no electric current through the mornings and rains in the afternoons made the use of both expedient. After that, the drying was completed on open shelves within doors at ordinary temperature. This process gave excellent results, the pods curing up well and crystallizing beautifully in drying.

. In dipping a thermometer must always be used, as the temperature has a most decided effect on the curing. Rabak states as follows:[1]

> Curing the beans at room temperature either without previous treatment or after treatment with water up to 90° C. for a short period of time apparently produces beans of the best quality, as judged by the flavoring extracts prepared from the samples. It is, however, essential that the temperature (of the water) be not sufficiently high to destroy the action of the oxidase which is present in the pericarp. A destruction of the oxidase would seriously interfere with the formation of the odorous constituents of the cured beans.

Dean and Schlotterbeck state:[2]

> That the production of vanillin in the bean is an enzym action has been shown by obtaining two green beans from Mexico and heating one to 80° C. in order to destroy the natural enzym present, and then submitting both beans to a curing process. The bean which had not been heated produced vanillin while the heated one did not.

Of course, immersion in water heated to 80° or 90° C. for short periods does not raise the beans to this temperature. It should be borne in mind that the relation between the volume of water and the quantity of beans dipped must be such that the dipping will not reduce too greatly the temperature of the water.

While hot, the beans are placed in a close receptacle to sweat, Some growers use half-hogsheads with close-fitting wooden covers. the beans first being well wrapped in blankets. Sweating continues until the following morning or even the morning after that.

It has been found in tests at the station that where only very small quantities are cured, those wrapped in a blanket and furnished no additional heat from without do not retain sufficient heat for proper sweating and that many beans develop watery blisters. Placing the beans immediately after dipping in a heated chamber to begin the drying process reduced the blistering to less than 2 per cent, whereas under the system of attempted sweating of small quantities without artificial heat the blistered pods in the different lots ranged from 20 to 50 per cent. However, samples of the sweated and the unsweated beans were examined by an expert in the manufacture of extracts and the unsweated beans were pronounced inferior to the sweated beans.

On removal from the sweating box (in which the beans should have changed to a chocolate color) the beans are spread for a few hours uncovered in the sun. After that they may be sunned under blankets for from four to six days. One grower has used a glass house with success, and he considers that this has greatly reduced the expense of curing. Others, instead of sunning, use artificial heat in drying, beginning with a chamber heated to about 110° F. After the pods become somewhat wrinkled they are removed from this to a less heated chamber for a short period. Whichever process is used

[1] Rabak, F. The effect of curing on the aromatic constituents of vanilla beans. Jour. Indus. and Engin. Chem., 8 (1916), No. 9, pp. 817, 821.

[2] Dean, J. R., and Schlotterbeck, J. O. Vanilla extract. Jour. Indus. and Engin. Chem., 8 (1916), No. 7, p. 608.

for the earlier drying, the curing is completed with the pods spread on shelves at ordinary temperature. The pods should be stirred frequently while on the shelves to promote uniformity in drying and for the removal of moldy pods.

The degree of dryness demanded by different markets varies, the American market preferring a drier bean than the European. The important point is to dry sufficiently to insure good keeping qualities. When sufficiently dry, the beans should still be supple, never brittle. One indication of nearly completed curing is that the contents of the pod slip along easily when pressed between the fingers, but the pod should not feel soft and mashy. The time which must elapse between picking and becoming sufficiently dry for storing away varies with the bean, this being for some very short thin pods only about three weeks, while very long fleshy pods may require more than three months. Six to nine weeks would be a fair average time.

Upon the completion of the drying process the beans are stored in tins with close-fitting tops and should be examined frequently for the removal of moldy pods. Many beans which have started to mold may be saved in part by cutting away the moldy portion. The sound fragments from moldy pods should be inspected frequently until all which are not going to keep well have been discarded. If before marketing the crop is kept several months after curing, most of the pods which are apt to mold can be seen and removed.

PREPARATION FOR MARKET.

Vanilla beans are sold by weight. The manner of presenting them on the market varies with the source of the beans, some being sold loose in bulk, others sized and done up into bundles of 50 to 90 beans each.

The ratio of the weight of fresh to dried beans varies with different curers and is said to range from 4, or even 6, to 1. In the 1917 station crop, the weight of the fresh beans was to their cured weight as approximately 4 to 1. The New York dealers to whom this crop was submitted reported it as very nicely cured but thought that the drying should have been continued until the beans were considerably firmer. The number of beans per pound for each length from 4 to 8½ inches is shown in the table on p. 27.

The beans make a better appearance if they are wiped with a soft cloth before bundling, but if crystallization has begun the crystals should be left untouched.

Sizing must be done by hand. A convenient measure for the purpose is made by marking on a sheet of paper a scale with quarter-inch divisions between 4 and 10 inches. This is pasted to the lower side of a pane of glass which can be cleaned easily. This should be placed on a table of sufficient size to accommodate all of the different

lengths in orderly arrangement with the most common sizes nearest the operator.

In bundling, the straightest pods should first be put aside. Several of these are needed for the core and others for the outside of the bundle, as a wrapper of straight pods gives a much neater appearance. The curving stem ends should be turned in as much as possible. When the final pod has been placed a few turns of cord or raffia will temporarily hold the beans in place until the bundle can be tied permanently near the two ends.

As sizing, polishing, and bundling the beans must all be done by hand, it would perhaps prove rather costly if the work were paid for by the day. Amateurs were timed for the different operations and it was found that about 10 beans were sized in a minute or 9 beans polished, and that a neat bundle of 50 beans was easily done up in 15 minutes or less. Practiced hands should of course greatly reduce the time required for these operations, and they should not prove too expensive if paid by the job at so much per pound or bundle. Neatly bundled beans make a much better appearance, require fewer containers, occupy less space in shipping, and are more easily handled than the loose beans, but bundling entails a considerable amount of extra labor. As vanilla beans of high grade are sold on the New York market both bundled and in bulk, the preference of the buyers must determine which method shall be followed by Porto Rican vanilla growers. It is reported from New York that the tendency is to sell beans in bulk and not to bundle them.

Vanilla is generally shipped in closed tins which are packed in wooden cases. Vanilla has a solvent action on several metals, including tin, but this action is much slower on tin than on a number of the others. On account of this solvent action the beans should be protected from contact with metal by lining the containers with paraffined paper or coating the inside of the container with paraffin.

SUMMARY.

In spite of conditions admirably adapted for the production of vanilla, this crop has never been grown commercially in Porto Rico.

While the price of vanilla is not what it formerly was, the consumption has increased greatly.

An import duty into the United States of 30 cents a pound means an advantage of exactly that amount for vanilla grown in Porto Rico.

Extract made from beans grown locally has been pronounced of excellent quality. From the reports of dealers to whom beans have been sold or samples submitted, this vanilla is worth from $2 to $4 a pound under the market conditions of the last two or three seasons.

From a small plat the crop (which was marketed at less than four years from the time the cuttings were set) averaged about one-third pound cured beans per fruiting vine. The gross returns from the sale of this crop were at the rate of a little less than $400 per acre. The year following, the yield averaged more than one-half pound cured beans per vine. This crop was not sold, but from valuations placed on samples submitted to vanilla dealers it would have yielded gross returns at the rate of approximately $700 to $900 per acre. The crop of the following year from these and younger vines on a one-tenth acre plat amounted to 36.44 pounds and sold for $109.31.

In starting a vanillery, the land should first be cleared and then planted with the trees which are to support the vanilla vines.

The dwarf bucare (*Erythrina corallodendron*) has proved well adapted for this purpose, and it is easily propagated from cuttings.

On steeply sloping land the rows should run with the contour lines of the slope and should be terraced in order to retain a mulch around the vines, as vanilla roots grow much better in a leaf mulch than in soil alone, and the maintenance of a good mulch of decaying vegetable matter is important.

Long cuttings make much more rapid growth and come into production sooner than short ones.

The shade trees must be pruned to avoid too dense a shade, which is detrimental to the development of the vines. A light shade admitting checkered sunlight is preferable to full exposure to the sun.

The rapid growth of the succulent, brittle vines demands frequent attention from the planter to keep them in proper shape and within easy reach for pollinating.

Hand-pollination must be used with vanilla. The number of blossoms pollinated has a most pronounced effect on the size of the beans. The pollinator may choose between a limited number of handsome, well-developed beans and a larger number of short, inferior, poorly developed ones, since the blossoms are generally produced greatly in excess of the number of beans which the plant is able to develop properly.

Labor for pollination is needed principally in March and April; for picking the crop from September or October to January; and for curing and preparation for market from picking time to late spring.

As the various operations require a considerable expenditure of time, care, and money, anyone who is unwilling or unable to give the requisite attention to this crop should not attempt its production. Under proper management, however, it should prove highly profitable.

The small bulk and imperishability of the finished product commend vanilla culture, particularly for such districts as are accessible only by poor roads over which bulky and more perishable produce can not be carried.

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